and of fresh leaf of *P. crassipes*, from Mr. Baxter: abundance of raphis-cells, and of crystal prisms, especially in the pith.

*Xyridaceæ* and *Juncaceæ*.—Bits of dried leaves of the three following, from Mr. Baxter:—*Xyris laxifolia* and *X. subulata*: no raphides. *Philydrum lanuginosum* (Xyridaceæ?): numerous acicular crystals lying singly along the leaf, the margin of which consists of prosenchyma, its transparent fusiform cells as long as in many sorts of woody pleurenchyma. Raphides were not seen in any of the few species examined of the British Juncaceæ.

*Palmaceæ*.—Cocoa-nut (*Cocos nucifera*), Palm-nut (*Elais guineensis*), Betel-nut (*Areca Catecu*), and Date-fruit (*Phœnix*), from shops: no raphides. Of the following, portions of leaves merely, when not otherwise noted, from Mr. Ward's fern-house, and from Mr. Moore, Mr. Sowerby, and Mr. Baxter:—*Rhapis flabelliformis, R. Sierotzik, Elais guineensis, Latania borbonica, Phœnix leonensis, P. dactylifera* (root, stalk, and leaf), *P. farinifera, P. sylvestris, P. humilis, Elate sylvestris, Seaforthia elegans, Chamærops*, two sp., *C. humilis* (bits of root and leaf), *Corypha australis, Areca alba* and *A. rubra*: raphides either not present or very scanty. *A. crenata, Thrinax parviflora, Chamædorea*, sp., and *C. Scheediana*: a few raphides. *Areca sapida, Sabal umbraculifera, Ceroxylon Andicola*, and *Caryota urens*: many bundles of raphides.

*Pandanaceæ*.—Leaves, from Mr. Moore and Mr. Sowerby, of *Pandanus utilis, P. spiralis*, and *Carludovica purpurata*: a profusion of raphides, the bundles of which are much shorter than their delicate translucent cells. Of this order, Prof. Balfour long since observed, "their spermoderm has numerous raphides."

Edenbridge, April 7, 1864.

[To be continued.]

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## XL.—*Histological Researches on the Formation, Development, and Structure of the Vegetable Cell.* By Prof. H. Karsten.

[Continued from p. 290.]

### § III. *On the Polarity of the Joint-cells of* Cladophora glomerata.

In an investigation of cell-development, *Cladophora glomerata* cannot be passed over, as its course of development furnished the foundation for the first theory of cell-formation, Mohl having employed it in his important and suggestive researches upon this subject—researches which have been repeated by all succeeding vegetable anatomists, who, almost without exception, have confirmed the results obtained by that highly esteemed observer.

If, notwithstanding, I now find, after the repeated and most careful examination of this interesting plant, that the law of development laid down by me is followed also in the formation of the cells of *its* tissue, particular difficulties must indeed have been thrown in the way of the recognition of the true phenomena by the structural conditions of this plant.

And it is undeniable that such hindrances do exist in the mode of development of the cells of this plant,—dependent, in the first place, upon the existence of a large number of secretion-cells in the vegetation-cells concealing their youngest phases and rendering observation difficult; secondly, upon the fact that in the tissue-cells the youngest joints do not, as is commonly the case, remain a long time undeveloped and exhibit their characteristic nucleus; and thirdly, upon the circumstance that the successive endogenous development in this plant proceeds in a high degree even in the secretion-cells, whereby the distinctive characters of the vegetation- and of the secretion-cell become confused and lost.

It is partly by these circumstances that the recognition of the true developmental processes in this plant has been rendered difficult (as indeed Jessen has shown by the communication of his observations on various Algæ), but partly also by the method of investigation, in which chemical reagents have been employed as physical aids.

In the following account I shall relate my observations in the order dictated to me by the opportunities I had of making them upon the developing plants.

It has been noticed, in the case of several Algæ, that individual cells detach themselves from the cell-tissue of the organism, become free like gonidia or the buds of more complex plants, and at length produce perfect individuals. This phenomenon (which takes place in nature under certain, though as yet not fully understood, conditions) may be artificially produced in the *Cladophora glomerata*, and probably also in the other Confervæ allied to it.

On cutting a *Cladophora glomerata* longitudinally into small pieces, so that a cell remains in each portion uninjured between two cut ones, and on placing such sections in water (Pl. VI. figs. 30 & 48), a portion of the mucilaginous granular contents is seen to escape from the cut ends of the cells, whilst another portion will become progressively changed and dissolved by the intruding water. The single uncut cell, however, resists the action of the water at its internal transverse septa, now freely exposed, as well as at the cuticle clothing its lateral walls, which does not permit diosmosis to take place in sufficient amount to exert an injurious action upon the assimilative activity of the enclosed cell. The cell thus isolated proceeds in its development, although at first slowly and in an altered form; for from it, just as from a germ-cell, a perfect individual is produced.

The first perceptible change in the cell is a state of tension of each of its free transverse walls or septa. These transverse septa present, in the normal uninjured state of the Conferva, a flat disk; but after the section of the neighbouring cells, they become somewhat expanded and pressed outwards from the ends of the uncut cell, so that they present a concavity towards the interior of this cell (Pl. VI. figs. 30, 31).

This extension, which is at first exerted equally on both walls, soon acts only upon one of them, and this is always the one which is naturally the lower one—a circumstance which can be best verified in such sections as have a cell branching from them (figs. 30, 31, 42). The enlarging uninjured cell now usually first of all pushes the original lower septum further downwards, within the cut cylindrical lateral wall, the diameter of this cylinder being generally not entirely occupied, by which circumstance the progress of the enlarged transverse septum may be distinguished far downwards. This inferior prolongation of the cell gradually becomes smaller in diameter and thinner than its upper portion (figs. 33, 34, 35), and it is also frequently not so thickly occupied with chlorophyll (figs. 42, 45) as are the normal joint-cells of the plant. At the same time the inferior extremity of this prolongation usually affixes itself to some dead or living organic body, it may be to a living cell of its own species, extends itself upon this in thin ramifications, and adheres closely to it (Pl. VI. figs. 43, 44, 45), by becoming intimately amalgamated, without, however, exerting any perceptible influence upon its vital activity. This direct inferior prolongation of the Conferva-cell thus becomes its radical extremity.

The upper end of the same cell follows an entirely different course. At first, indeed, the septum exhibits a certain degree of extension like the lower one, but I have never distinctly made out a direct elongation of the apex of the cell upwards into the empty cell above; but when an act of growth is established in the upper extremity of the cell (an event commonly subsequent to the extension of the lower end), this expends itself laterally below the transverse septum so as to produce a branch,—the proceeding resembling that whereby ramifications are normally produced in uninjured Confervæ.

The branch therefore is developed within and under cover of the original enveloping membrane of the entire plant, whilst, on the contrary, the organ which represents the root of the higher plants is not covered by this general integument, but, so soon as it has emerged from the surrounding walls of the cut cell, continues to elongate itself in the water quite free and unclothed.

We here find, therefore, in the development of these two physiologically different organs, a similar phenomenon to that which obtains in compound plants; for all those parts of vascular plants which belong to the ascending axis are clothed during their development by the epidermis; whereas this covering is wanting to the root, whose divisions are invested with a layer of tissue analogous in many respects to cork, even at their growing extremities.

The normal phenomenon of root-formation from the original lower extremity of the cell of the Conferva, isolated in the manner described, and that of the production of a branch from its original upper end (exceptions to which rule are extremely rare) render it evident that in each of these cells there is a physiological difference between the two extremities. Moreover, in the case of the swarm-spores and gonidia of Algæ, which consist of only one system of endogenous cells, and are provided on one side with vibratile cilia, a similar pre-existent polarity may be recognized; for, in these, one side, and indeed that which is clothed with cilia, will always grow downwards into the root of attachment, whilst the opposite extremity of the spore, invested by the thickened mother cell, grows upwards to form the stem. This separation of the regions of the cell by reason of their endowment with different functions, which is already established by development in the parent plant, forms the basis of the dissimilarity in the arrangement of the organs of the developed plant.

In part it is the mode of nourishment of the spores and germinal cells, dependent on their position in the mother cell and in the parent plant, which engrafts upon the cell, simultaneously with its production and development, the dissimilarity in the functions of its different regions.

In part, also, this heterologous activity at the opposite poles of many germinating spores of Algæ and of the phanerogamic embryo in course of development, is probably founded in the anatomical difference of these poles—the extremity of the young organism which takes on the function of a root breaking through the mother cell which continues to envelope the opposite extremity as an enclosing membrane, or at least envelopes its youngest parts until the complete evolution of the normal form.

We may further look upon the vibratile cilia with which the germinal corpuscles are furnished as in part a cause of their polarity; for the cilia themselves, being extended hair-like secretion-cells (Bot. Zeitung, 1852), constitute the first simple organs of nutrition of the embryonic organism. Filled with a liquid which causes the taking-up of matters from the surrounding medium, these organs doubtless prepare the first nutritive matter for the cell upon which they are seated; and this matter will be applied, especially during the dissolution of the ciliary membranes, so as to promote or produce in the adjoining region the predisposition to take on the function of a root.

Those germ-cells (gonidia) which are clothed with a uniform ciliary epithelium, as, for example, those of the genus *Vaucheria*, display no such polar tendency at their opposite ends.

On the other hand, similar conditions are encountered in the developing germ-cells of the complex organization of phanerogamous plants. In these also the mystery of the normal position of the radicle of the young plant with regard to the micropyle (independently of the mode of attachment of the ovule to the placenta, from which it receives its nourishment) will undoubtedly find its partial solution in the fact that the first impulse to the assumption of the typical form of the mature organism, which is innate in the fertilized cell, is derived from the contents of the pollen-sac, which penetrates into the ovule through the micropyle and determines the polar property of the indifferent germ-cell.

In the filiform Confervæ, this polar property of the germ-cell, when once set up, propagates itself to every cell, in series, throughout the organism, and is equally stamped upon every single cell in it; and the same thing takes place in the Phanerogamous plants which are composed of various kinds of tissues, by which we may explain the predisposition to polar activity inherent in every fragment of the stem or leaf, which manifests itself in the normal development of new roots at the originally inferior extremity of the organic fragment.

The desire to make this phenomenon dependent on the presence of vessels which are endowed with functions analogous to those of animals (which, curiously enough, has been quite recently again put forward) arises from a complete misconception of the structure of the tissues of plants.

## § IV.

The joint-cells of *Cladophora* are at a certain period filled with a tissue composed of secretion-cells, which arise along the middle of the cells and extend themselves to the periphery, where they dissolve.—Some of these secretion-cells have their membranes thickened.

According to the opinion now generally received, most of the tissue-cells of plants consist, at a certain period of their life, of an external membrane, a primordial utricle (second cell-wall inwards), a nucleus containing a nucleolus (the third and fourth inner cell-walls), and between the nucleus and primordial utricle a considerable amount of cloudy, granular, mucilaginous fluid—the protoplasm, plasma, or cell-juice. In this last, during the enlargement of the two outer cell-walls, irregularly disposed cavities or vacuoles are formed, which separate the rest of the granular mucilaginous contents into two portions,—namely, a central portion surrounding the nucleus, and a peripheral one, lining the inner surface of the primordial sac; but the two are united by simple or branching fibres extending between them.

In the cells of *Cladophora* no nucleus is visible. Their plasma is described as mucilaginous, of greater density at the surface contiguous to the second inner cell, where it contains much chlorophyll and starch (and, according to Nägeli, hardens to form the inner sac [*Innenschlauch*]). The state of matters in this instance, however, is somewhat different; and a thorough discussion is necessary to enable us rightly to estimate the organization of these cellular plants, as also that of the plant-cell generally.

The contents of *Cladophora glomerata*, which escape when a section of the plant is made under water, are for the most part readily destroyed by the action of the water, so that only the corpuscles of chlorophyll and starch, and, at a later period, only those of the latter, can be discerned. These starch-vesicles frequently constitute the nuclei of the chlorophyll-grains, and advance in growth within them during the liquefaction of their substance. Further observation of the exuded substance of the wounded joint of the Conferva, whilst submitted to the action of water, will show that this apparently mucilaginous fluid consists of hyaline vesicles and cells, which are filled with a transparent liquid, either quite colourless or in part coloured by a greenish matter. The latter, where present, adheres like a green mucilage to the surfaces of the very delicate envelope of the cells, coats them externally or internally, and often entirely fills their cavity. The size of these vesicles varies from the most minute to others whose diameter considerably exceeds the transverse diameter of the Conferva. However, the determination of their original dimensions is very difficult; for all of them, at the moment the section of the Conferva is made, and upon coming into contact with the water, undergo an extraordinarily rapid and considerable distention, and mostly soon rupture. By causing movements in the water, the escaped delicate and yet unruptured cells may be made to roll and demonstrate the resistance to water which their membrane enables them for some time to maintain. Moreover similar delicate cells may be observed in the emptying portion of the cut joint-cell, adhering here and there to the inner surface of the secondary membrane. The central cavity of the joint-cell becomes eventually filled with water, or, it may be, with air, if the latter has been allowed to enter during the making of the section.

Several small vesicles and thin-walled cells, of the same sort, are very commonly met with enclosed within a larger and equally delicate common cell-membrane. This outer wall, which lies at first in close apposition with the inner cells, becomes, by the imbibition of water, much removed from them, and, by the longer operation of endosmose, gets so much stretched that it becomes ruptured at some point, whereupon the hitherto smooth and structureless membrane suddenly collapses, appears granular, and proceeds to dissolve, commencing from the gaping margins of the fissure.

The vesicles and cells imbedded in colourless or greenish mucus, set free by the dissolution of the mother cell, are now likewise exposed to the action of the water, to which they yield in just the same manner as the others, usually bursting in the course of ten or fifteen minutes. If the water be only in small quantity, the expanded membrane is preserved in the surrounding mucilage for some time longer.

Former observers have remarked similar phenomena: as, for example, Meyen, in the case of the gonidia extruded from joint-cells; Saulier, in those of *Derbesia*; Unger, in *Achlya prolifera*; Itzigsohn and Hartig, the latter in *Vaucheria dichotoma.* Nevertheless they have all taken a different view of these insufficiently noticed facts; for they have looked upon the mother cell cast off from the daughter cells in the course of endosmosis (following the hypothesis of Mirbel) as originally a secreted layer precipitated around them.

Hartig says that, upon cutting through a *Vaucheria,* cell-vesicles may be seen emerging and separating themselves from it by constriction, presently bursting and emptying a portion of their fluid matter, and then, by the contraction of their integument, closing again, and swelling up anew. Moreover he affirms that two or more sacs which have been cut through may coalesce by a sort of conjugation into a single vesicle.

By repeated investigations respecting these phenomena, I have convinced myself that these apparent detachments, contractions, and repeated dilatations are nothing else than the successive expansion and dissolution of an endogenous system of cells. Those vesicles which have once burst or been cut through never unite with one another or become again distended by endosmosis, as Hartig believed he had seen them do; but they undergo a continuous breaking up. The uninjured superimposed cells in close contact with each other are with difficulty recognizable, on account of the great delicacy of their membranes, when their contents are uncoloured, and consequently they appear to form only a single cavity. By adding to the water in which the cellular contents of the Conferva are lying a watery solution of iodine or tannin, the phenomena of distention and bursting take place much more rapidly in the colourless endogenous cells, especially with the latter solution, whilst their contents remain uncoloured and readily mingle with the fluid.

Sometimes, immediately on cutting through a Conferva in water, a large thin-walled cell, of half the length of the joint-cell and equal to it in diameter, may be seen to emerge gradually: it is filled with other vesicles, partly clear and transparent, and partly coloured green and containing chlorophyll- and starch-corpuscles. It looks, in fact, as if an entire young joint-cell were thrust out from the cell of the Conferva. After a short time, the outer wall (the mother cell of all these enclosed cells) dissolves in the water, and either suddenly vanishes in its whole circumference or its solution proceeds from one extremity and advances throughout its entire extent, when all the enclosed corpuscles, previously recognizable only by the flattening of their contiguous walls, project more or less above the surface of the conglomeration, and, expanding continually, at last burst and suddenly disappear.

The phenomena are different when the section of the Alga is effected in a solution of gum arabic instead of under water. Then, as the fluid penetrates into the cut Algal cell, no green cells, and scarcely any but perfectly limpid cells, make their appearance; and these present a more deceptive resemblance to drops than even in water. They may be seen to exude in succession from the interior of the Conferva joint-cell in great abundance and of very various dimensions, and, as they approach the aperture, to increase in size, and soon entirely stop it up. Sometimes they are coated with a green slime; sometimes this is collected into a larger mass, which is surrounded by the transparent cells, and in which they are imbedded.

On gradually adding water to the solution of gum, these hyaline cells, usually called vacuoles, are seen to swell up gradually until they collapse suddenly, when their contents mix with the water, and their membrane shrivels up, but for the most part is not dissolved. The green mucilaginous masses likewise now begin to swell, and it can be distinctly perceived that these are the vesicles filled with green mucus which collapsed in the solution of gum, whilst their membranes enveloping the green slime are now again distended in the water.

The membranes of the cells filled with a colourless strongly endosmotic fluid, which have burst in the water, may be treated with corrosive reagents without being immediately dissolved.

On submitting them to an aqueous or alcoholic solution of iodine, it is found that that reagent does not perceptibly colour either the contents or the membrane of these cells. The same holds true, in the main, when the solution of chloride of zinc and iodine is employed, when the shrivelled membrane is scarcely coloured pale yellow.

Moreover these phenomena are modified not only by the stage of development of the plant, but probably also by variations in the conditions of nutrition, as the researches on *Spirogyra,* hereafter to be described, have further shown.

From the foregoing remarks it follows that the joint-cells of *Cladophora glomerata* do not contain at all periods of their development a mucilaginous, granular, viscid fluid—the "gonimical contents" of Kützing or the "protoplasm" of Mohl; but that, at certain periods, they are entirely filled, as if occupied by a perfect cellular tissue, with thin-walled strongly diosmotic cells, which, on the one hand, enlarge in water with extraordinary rapidity, and, on the other, shrivel up in solution of gum.

The nature of these endogenous cells is twofold. Thus some of them contain, besides a colourless watery fluid, often also without this, a larger or smaller quantity of a green mucilaginous matter (both materials being very probably enveloped in special cell-membranes), and, floating freely in the latter substance, either small vesicles of starch and chlorophyll (the latter frequently containing a starchy nuclear vesicle) or smaller and larger cells, in which these bodies are then contained. Their membrane is distended, and soon becomes liquefied in water.

The cells of the second description are filled only with a clear transparent liquid, and very rapidly absorb water until they are burst and destroyed by it. They are therefore difficult of observation, unless the water is duly mixed with gum, so as to retard the distention of the diosmotic membrane, when it becomes possible at times to demonstrate that the membrane of many of these cells is corroded, but not dissolved, by water and solution of chloride of zinc and iodine.

Between these two kinds of cells intermediate forms occur, showing that the two forms are not of an entirely different nature, but only different stages of development of one and the same kind of cell.

The phenomena observed during the action of fluids on the cut joint-cells and on the expanding endogenous cells which issue from them, as also the position of the latter in the uninjured and normally grown joint-cells, indicate that the cells consisting of watery contents and more resistent membranes occupy the median line of the cylindrical joint-cell of the Conferva, whilst those filled with chlorophyll, and whose membranes are soluble in water, occur nearer to the surface than this central tissue.

Moreover, at the extremities of the joint-cells of perfectly normally developed plants, the limpid cells—pressed together until they assume polyhedral forms, which occupy the central space of the joint-cells—are seen (as in fig. 31 $x$) pushing forwards beneath the cells filled with chlorophyll which occur on the surface.

During the period of the multiplication of the joint-cells, either the larger of these endogenous cells filled with secretory matter are, as it would seem, entirely absent, or else those are chiefly present which enclose in their readily soluble membranes the smaller ones containing chlorophyll and starch. These can then only be recognized in the vicinity of large endogenous cells which are no doubt developed into new joint-cells.

The relative proportion in which these two forms of endogenous cells are present, and their consequent position in the joint-cell of the Confervæ, cause the wide range in form which prevails in these plants.

As the mode of development and distribution of the endogenous cells is dependent upon the nutrition of the plant, and consequently upon the chemical composition of the fluid in which it grows, the cultivation of *Cladophora glomerata* will furnish important materials for a revision of the systematic value of those forms.

The great tendency to the diffusion of fluid which the transparent cells exhibit causes these cells, when the uninjured plant is placed in a solution of tannic acid, to expand greatly and to become visible on the surface after some time has been allowed for the reagent to act. This reagent will frequently bring to light the presence of cells within joint-cells, even although before quite invisible, the whole substance looking like an unorganized mucilage. This is well seen in the case of the colourless contents of the joint-cells of *Mougeotia,* in the median line of which the single mass of chlorophyll appears to float freely, surrounded by a colourless homogeneous fluid. This latter, however, is found to consist of a mass of closely placed, rather elongated, or often somewhat cubical cells, by the expansion of which in a spiral direction the twisted form which the chlorophyll often exhibits is produced.

These cells likewise usually become very distinct in the joint-cells undergoing enlargement alongside wounded joint-cells, after they have remained for some time in pure water, and thus give the surface of the plant a largely cellular reticulate aspect.

In Pl. VI. fig. 39, an instance is figured of the expansion of one of these endogenous cells to half the dimensions of the joint-cell, without having new cells formed within its cavity.

The great delicacy of the walls of the endogenously stratified (nested) system of these cells is an obstacle to the recognition of the plan of their arrangement and of the course of their development in uninjured plants; whilst their extreme fragility when separated from their organic connexions renders it impossible to ascertain, with regard to the tissue-cells, whether the binary combination obtains with them as the external phenomena of development render probable.

It would appear, as before observed, that the cells filled with colourless fluid occupy the median space of the joint-cell, and that, towards the outside, these pass into the series containing chlorophyll, probably becoming converted into them. This mode of development would not be in favour of the prevalence of the binary type, if we did not know that most of these cells only exercise the function of secretion-cells, and that they become overgrown (that is to say, pushed aside and dissolved) by one or more cells becoming developed into tissue-cells: first their proper membrane, then the nitrogenous vesicle enveloped by them, and finally the secretion-vesicles, rich in carbonaceous compounds, are absorbed.

In a thick-walled form of *Cladophora*, I repeatedly observed (Vegetationsorgane der Palmen, 1847, p. 30) that, in somewhat diseased cells, a number of these endogenous thin-walled cells containing chlorophyll acquired walls as thick as those of the joint-cell itself; and in *Cladophora glomerata* small interposed joints are not unfrequently met with (as shown in fig. 30 *a*), which I look upon as separated secretion-cells which have exceptionally acquired thick walls and passed into the series of tissue-cells, instead of having been absorbed by the vegetation-cells in course of normal development.

In diseased and withering joint-cells of Confervaceæ we frequently meet with individual examples of these endogenous cells, which contain only starch or are completely empty.

## § V.

Mode of development of the radical extremity of the cell of *Cladophora*.—Formation of folds in the coats of the adjoining withered cells.—Joint-cells of the root-cell.—Independent growth of their cell-membrane.—Folds in the assimilating membrane of the joint-cell, and their causes.

During the previously described downward growth of the joint-cell of *Cladophora*, not only its proper membrane, so far as this forms a septum, but also the immediately contiguous wall of the neighbouring cell, extends itself in the direction of the cut surface. The latter is seen thrust backward within its own cavity as the former is extended into this (Pl. VI. figs. 31 & 33). Very soon, however, this backward-pushed wall of the cut cell, which is at first somewhat swollen and thickened, as in the uninjured condition, becomes lost to view at the extremity of the advancing growth from the neighbouring cell (figs. 35, 37, 38,

& 39). It is only at the spot where it formed an annular fold, in consequence of its depression, that it is any longer visible, very strongly thickened, often in layers.

In the course of the further development and outgrowth of the adjoining living cell, this membrane of the inverted cell, which thus serves the living cell as an external envelope comparable to a *cuticle*, is absorbed in the same way as the intermediate substance and cortical tissue which is dissipated before an adventitious root. (See my account of the Organs of Vegetation of the Palms, pl. 4. fig. 8.)

This absorption of the inverted septum (figs. 37, 38, 39, & 42 *a*, *b*) proceeds from below upwards (from the centre towards the periphery), in such a manner that the rather thick fold is, at a certain phase of development, the sole indication of the displaced septal wall; it then surrounds and somewhat constricts the daughter cell, in the form of an annular fibre, within the enveloping membrane (fig. 42 *a*; the immediately preceding stage of this fold is represented at *b*).

This structural condition occurs not only in the course of artificial preparations, but also very frequently as a consequence of injuries in the course of the natural growth of the plant. These annular folds, when their origin is not recognized, may easily be mistaken for those others which have been regarded as incipient and suppressed septal structures.

The remaining cylindrical dead wall of the cut joint-cell sometimes presents a delicate, though very definite, longitudinal striation (figs. 31, 33, 35).

Not unfrequently, moreover, a cell is prolonged, in the manner described, through two or more adjoining cells, on account of circumstances operating prejudicially on their vitality; and we then find on the surface of these long joint-cells several annular folds situated at distances determined by the length of the original cells.

It is the general, but not universal rule, that the development of isolated joint-cells proceeds in the manner illustrated in figs. 33, 34, & 35, the adjoining dead cell-wall being regularly and equally invaded by the growing cell, and apparently expanded passively. At times one side or one portion of the septum appears to offer greater resistance than the rest, or else the vegetative energy of the extending cell is more considerable on one side than in the median line; and the consequence is the production of irregular forms of the annular rings, as exhibited in figs. 37 & 39 *a*.

It also now and then happens that the growing cell, when it has just advanced into the cavity of the cut cell, does not thrust the whole area of the septum downwards before it, but, as shown in figs. 36 & 38, only the central and less thickened or entirely unthickened portion of it, inflating it at first in a globular form, and subsequently occupying more or less completely the entire space of the lower cell.

In the normally developing septum the increase of volume of the assimilating and growing cell-membrane (fig. 40 *a*), which manifests itself as a thickening, commences at the periphery, and advances hence in the cylindrical part of the membrane towards the ends of the two cells, in accordance with the growth of their mother cell; in the septum itself the advance is towards its central point.

If, by the stronger endosmotic distention of the neighbouring uninjured cells, a greater pressure is exerted, soon after the cutting of the cell, upon a septum of this kind which has not long become liquefied, the septum is not grown through as above described, but it is suddenly ruptured, and the contents of the neighbouring and previously uninjured cells are pressed out through the opening.

A similar laceration of the new septal wall and escape of the contents of a cell into the neighbouring cells, after the operation of endosmotic fluids, takes place also in uninjured cells, and appears to have furnished earlier investigators with support for the idea of a septal formation by the growing in of a fold of the parietal part of the membrane of the mother cell as far as its middle line.

Sometimes the downward-growing lower end of the upper cell does not thrust the transverse wall before it in the median line, but to one side, so that its lengthening extremity presents on one side a very narrow, and on the opposite a much wider, annular fold as the remnant of the original septal wall (figs. 37 & 39 *a*).

I have more frequently observed instances where the downward growing cell has not prolonged itself within the next dead or cut cell beneath, but has thrust this entirely to one side, so that the two cells appear in apposition, longitudinally, like two wedges lying in opposite directions.

Sometimes connected Conferva-filaments are met with in which some single cell has become diseased and withered, and then the immediately superior cell has grown in the form of a root-cell into the cavity of the diseased cell, down to its bottom, forming the next lower septum. This portion which has grown down then begins to enlarge, until it entirely fills the cavity of the diseased cell, and its lower extremity forms a perfectly normal septum with the neighbouring cell.

The very long joint-cells thus formed become, just as in the case of the root-like cells produced from injured Conferva-cells, subsequently divided into joints (sections) by the formation of endogenous cells.

The first indication of young joint-cells in the root-cells, both in their extreme points immediately within the enveloping membrane (fig. 32) and in the interior of the joint-cells already present, consists in the appearance of a continually enlarging cell, which at first shimmers through the chlorophyll, but afterwards becomes free in its median part by the displacement of the chlorophyll, and exhibits in its interior small vesicles, the rudiments of new cells. I have not completely traced in one and the same root-cell the entire absorption of the chlorophyll, starch, &c. which at first separate the daughter cells of the second order; but I have seen, in different individuals, all the transition-forms up to states in which there were no longer any organized bodies between the two new joint-cells of the root-cell, but only an apparently gelatinous, unorganized, intercellular substance, as represented in fig. 32.

The membrane of the endogenous cells of the root-cell always appears to be thicker at the lower than at the upper end; therefore where two cells are in immediate contact, the portion of the lower cell entering into the structure of the septum is easily overlooked, especially as it is here not only a very thin membrane, but also somewhat thrust backward by the convex extremity of the contiguous thickened cell.

At the extremities of the stem and of the branches the opposite conditions are met with. We indeed equally find at times the contents of the last joint-cells composed of several thin-walled cells, as seen in Pl. VI. fig. 42 *a*, where the contents are distinctly divided into three segments, each enclosed by a delicate membrane. The upper extremity of the lowest cell here projects somewhat within the lower and concave end of that next above it; consequently the septa of these young cells (discoverable with the greatest difficulty) are not flat, but conical. The uppermost little cell discernible at the summit of a branch is filled with vesicles as yet scarcely coloured green. Similar vesicles are found at the extreme ends of root-cells: this serves to contradict the erroneous supposition that this Alga has no terminal growth. I have also observed a similar phenomenon in *Vaucheria* (*op. cit.* p. 90, pl. 2. fig. 2).

The apex of the root-cell, which is usually thinner (fig. 42) and ramified at its extreme end, where it is adherent to other bodies, generally of organic nature (figs. 43 & 44), shows a very remarkable independence in the growth of its outermost cell-membrane, which encloses the whole root just as the cuticle does the up-growing stem. This cell-membrane, independently of that of the enclosed cells, emits branches which become much thickened, frequently in layers (fig. 45), just as the cuticle is nodosely thickened sometimes in the same plant at the apices of the branches, and, in phanerogamous plants, frequently above each epidermal cell, apparently independently of the contents of the latter.

An independent growth similar to this of the cuticle, which grows out into knots, folds, and branches, is exhibited by the membranes of the joint-cells of *Cladophora glomerata,* which form inwardly annular folds, sometimes presenting a great resemblance to those already described as produced in consequence of penetration (figs. 38, 39); nevertheless they are readily distinguished, by the disposition of their parietal prolongations, from the latter, which are quite different from them.

The origin of these folds (fig. 40 *b*) of the integument of the secondary cells was observed both simultaneously with the commencing thickening of the membranes of the endogenous joint-cells, which come into contact in the normal septum (fig. 40 *a*), and also in those cells not undergoing the act of multiplication.

After the thickening and the chemical transformations associated with it have commenced in the cell-membrane, a progressive increase in thickness, but no elongation, is to be seen in these folds. Not unfrequently they encroach so far into the cavity of the cell as almost to reach the median line and nearly to divide the constricted cell-contents; nevertheless the still existing connexion between the two segments of the cell thus drawn apart continues unchanged.

Contemporaneously with the thickening in the membranes, there appears to exist in these cells, as long as this formation of folds is taking place, a tendency to expansion, the volume of the mother cell and enveloping membrane remaining the same, by which means the expanding daughter cell is compelled to grow into the cell-cavity in the form of a fold: this also occurs in the septa of many *Spirogyræ.*

The cause of the production of these folds of endogenous cells appears therefore different in nature from that which separates the daughter cells of the root-cell from one another (fig. 32).

The mother cell of the root-cell developes its membrane (cuticle) (which, as it were, takes on the function of the spongioles of vascular plants) predominantly in proportion as the included daughter cells expand themselves; whilst in the production of folds in the cells of the stem and branches the membranes of the daughter cells especially become enlarged, and are in this way productive of the folds, different forms of which occur in the other Confervaceæ.

The joint-cells engaged in this process of fold-construction (fig. 40 *b*) always seem to exercise a certain degree of pressure upon the neighbouring cells, which involves some impediment to their extension.

In the normal production of septa (fig. 40 *a*) no such tension exists in the subdividing cell.

Mohl, indeed, observed these folds, which he represented as originating in a disturbance of the process of constriction of the primordial utricle during continuous formation of membrane. Mohl saw these structures in specimens of *Cladophora glomerata* that had been kept for some time in fresh water.

I likewise found these folds frequently in cultivated specimens of this plant, but have no explanation to offer respecting the special cause of their production. In a specimen of *C. glomerata* which has been growing for a year in a very small vessel filled with distilled water, both these folds and septa of the normal form occur; and indeed the latter are the more frequent. In various other specimens, however, preserved also for a long time, though not so long as the former, in river-water, in plants covered with Desmidieæ, the normal septal development rarely occurs; still the multiplication of joint-cells has proceeded in these plants, though their differences in length are very marked.

The production of folds has here (fig. 40 *b*) occurred very largely, and in all forms; so that the idea suggested is that these inwardly growing folds are the commencement of septa. Still this is not the fact; for, as before stated, the folds, when once formed, undergo no ulterior change.

## § VI.

Formation of septa in the joint-cells of *Cladophora* by means of endogenous cells. The cell-membrane is rendered thicker in the vicinity of the annular folds by superposition.—Thickening of the membrane, in the absence of annular folds, by the superposition of extremely thin-walled cells.—Means of separating the superimposed cells of the thickened cell-wall by diosmotic fluids.—Action of these reagents upon new joint-cells.

In many stages of development of these infolded *Cladophora*-cells, we may convince ourselves, by slight pressure exercised upon a joint-cell engaged in the act of folding (as, for instance, during the gradual drying-up of the surrounding water, or during the sudden accession of fresh water in place of that which has been withdrawn), that its contents on either side of the fold are in direct communication, and traverse freely from one part to the other, which is not the case when a true septum is produced.

This phenomenon shows that no actual, complete septum, however delicate, is ever established in connexion with this fold; and it also indicates that the secretion-cells, which usually occupy the joint-cells, had here probably terminated their cycle of development, and left only their final and most highly developed products, in the shape of small vesicles freely moving within the juices of the cell, and destined for the nutrition of new joint-cells.

If such joint-cells, furnished with annular folds (fig. 40 *b*), be examined for some time, progressive, though very gradual, changes are observed to take place in the position of the secretion-vesicles. Here and there in the vicinity of the annular fold the sharp outline of a cell, apparently filled with colourless fluid, will make its appearance among the mass of secretion-material which occupies the joint-cell. This enlarges, and progressively advances towards the middle line of the fold. A similar process may be frequently witnessed going on simultaneously on the other side of the fold.

Lastly, the entire and somewhat rounded end of the cell may be observed free from chlorophyll close to the fold; the membrane, as compared with that of other young cells, is thick, but of a gelatinous aspect, whilst the contiguous thick membrane of the fold resembles that of woody tissue.

The two endogenous cells at last approach so closely together in the middle line of the fold, that, by their mutual pressure, they form a septum which, to those who have not followed its development, would appear as if it had been forcibly separated at its periphery by the annular fold.

In other cases, a cell arises on one side only of the fold, and continues to elongate itself beyond this, until it reaches the next septum.

The membrane of the fold appears, during the subsequent existence of the endogenous cells, to become absorbed; for we find that where these latter have thick walls, the former is thinner than when those cells were newly formed.

This mode of formation of septa by tolerably thick-walled endogenous cells, readily observable during their slow growth, is, however, of comparatively rare occurrence in *Cladophora glomerata*. Usually, in this plant, the commencement of thickening first calls attention to a pre-existent and fully developed although very delicate septum, this having been previously concealed from observation by the great quantity of secretion-materials with which it is covered.

In my account of the structure of *Vaucheria*, I showed that this so-called unicellular plant consisted of a composite system of endogenous cells, the innermost of which develope themselves and enclose organized secretory materials simultaneously with the absorption of the mother cells with their contents, but that the membranes of all these joint-cells do not become thickened, and therefore may easily be overlooked.

In *Cladophora glomerata,* whose endogenous cells have just been considered, a thickening of the originally very delicate membrane of certain endogenous cells occurs regularly, but only when these have acquired their normal size and by their contact and pressure concur in the formation of a transverse septum whilst, at the same time, the secretion-cells in their vicinity undergo absorption.

The more rarely occurring conditions of development described in the last section seem to me also to elucidate sufficiently the normal process, the essential relations of which can with difficulty be followed in the joint-cells when completely filled with chlorophyll and other secretion-materials.

Fig. 46 shows one of the joint-cells of *Cladophora* poor in chlorophyll and filled with the large colourless cells, such as are produced by cultivation in pure distilled water, especially when the plant has been cut into short pieces. The specimen has been subjected for a short time to the action of dilute glycerine, in order to detach the endogenous cells from the membrane of the mother cell. The membranes of these cells, though separated by a delicate septum, were not perceptibly thickened; by the action of exosmose they were contracted and also detached from each other at the septum ($x$), without leaving a layer of deposit between them. This happens also in the case of *Œdogonium,* as above described (p. 283), but appears to be of unusual occurrence.

The conviction is thus arrived at of the actual presence of free cells and of the origin of a septum by the mutual contact of their walls, even before any appreciable thickening, and without the agency of any involution or folding of the mother cell. Nägeli, indeed, noticed these phenomena, but nevertheless believed in the existence of inward-growing walls, which might be invisible either on account of their tenuity or of their containing a great amount of water.

One of the two thin-walled daughter cells represented in fig. 46 is seen at $q$ to be again divided by a distinguishable septum, in all respects similar to the septum displayed in *Œdogonium,* as observed at its origin and represented in figs. 21–29, and described at p. 277. This delicate septum would not be distinguishable if the inner wall of the mother cell were, as usual, coated with secretion-vesicles, until these were absorbed, and the later process of thickening set up in it. In the present case, the observation of this young joint-cell, which had been rapidly expanded in consequence of the injury done to the neighbouring cells, was rendered possible by the less degree of aggregation of the secretion-materials.

The cells that make their appearance on the section of a joint-cell of *C. glomerata* render it highly probable that these septa originate from the mutual contact of endogenous cells, just as is observed in the above-described annular folds and in *Œdogonium*, and that the septum which gradually becomes visible through the dense layer of chlorophyll, extending from the periphery to the centre of the joint-cell, is not then for the first time produced, but that its becoming visible only indicates the increasing thickness of the walls of the cells concerned in its formation by their apposition, just as has been fully described in *Œdogonium*.

In *Œdogonium* it may be distinctly demonstrated that the absorption of the secretion-matter contained in the cells in process of multiplication does not take place until after the enlargement of the endogenous daughter cells, and subsequently to the construction of the septum by their contact.

In *C. glomerata*, in the course of normal septum-formation (fig. 40 *a*), the largest portion of the secretion-matter situated externally to the two enlarging new joint-cells undergoes more or less complete absorption when these endogenous cells have so far advanced in growth as to constitute a new septum by the apposition of their walls, the nitrogenous compounds being the first to dissolve.

The absorption of the secretion-materials contained in the mother cell is concurrent with a new formation of them within the young joint-cells; therefore in *Œdogonium* this new production only takes place after the completion of the septum, whilst in *Cladophora*, on the contrary, it happens simultaneously with, or even before, this period.

If sulphuric acid, or a solution of chloride of zinc or of chloride of calcium, be allowed to act for some time upon a specimen of *Cladophora glomerata*, and a solution of iodine be then applied to it, a cloudy violet-coloured slimy layer, looking like finely divided iodide of starch, makes its appearance between the primary and secondary cells, resembling the lamina sometimes observed in the same locality in *Œdogonium* (p. 282) after the simple application of a solution of iodine to its tissues. Whether this material is the remains of the secretion-matter, as in *Œdogonium*, or is analogous to those other conditions to be discussed in *Spirogyra*, are questions requiring further research to answer them.

The examination of *Vaucheria* convinced me that the cell developed as a branch is formed within the stem-cell, and only projects from the surface simultaneously with the production of a branch-like process from the enveloping membrane. The same fact may be observed also in certain stages of the development of *C. glomerata*. The septum produced by the enlargement of two endogenous cells is not completed and does not become thickened before one of the two cells has extended itself more or less completely from the cylindrical cavity of the mother cell in the form of a branch. It might be imagined that it is so forced out by the contemporaneous predominant growth of the sister cell. This regular course of branch-formation is not, however, always thoroughly carried out; the lower extremity of the branch-cell frequently remains within the mother cell, and aids to form along with its sister cell a septum in the form of an oblique or horizontal thickened lamina.

The externally visible phenomena which accompany the processes of normal septum-formation in *C. glomerata* may readily mislead one into regarding the explanation given of them by Mohl as the natural one.

Having, however, ascertained that in the joint-cells of *C. glomerata* there is generally concealed beneath the superficial layer of secretion-cells a complete tissue of endogenous cell-systems—a tissue which certainly does not cohere, like the cellular tissue of more highly organized plants, by intercellular substance, or at least not by such as is insoluble in water and which consists, not of persistent tissue-cells, but almost entirely of transitory secretion-cells (for large mother cells may be seen, filled with cells of nearly half the size of a joint-cell, to swell forth from the cut joint of the Conferva),—having ascertained that the flat horizontal septum produced by the mutual apposition of these endogenous cells occurs already formed (fig. 46 *q*) in the secondary cell before this has become thickened, and having been able in certain cases, by means of endosmotic fluids, to divide this septum and to recognize its composition out of parts of two neighbouring cells (fig. 46 *x*),—having, further, even in *C. glomerata*, exceptionally seen septa normally formed by the mutual apposition of two cells originally separate (p. 419, fig. 32) and even belonging to different generations,—we shall feel called upon to submit the normal process of septum-formation in this plant to another examination in order to try to refer it to the general law of cell-formation.

Fig. 40 *a* (Pl. VI.) exhibits the phenomenon first witnessed by Dumortier (Nova Act. Leop.-Carol. 1832) and described in detail by Mohl, which is regarded by him and his followers as a folding of the walls of the joint-cells of *C. glomerata* in process of multiplication, and as the type of "cell-formation by fission."

Mohl (Vermischte Schriften, 1845, p. 623; Veget. Zell. 1851, p. 212; Botanische Zeitung, 1855, p. 689) supposed that the internal surface of the secondary cell (primordial layer) is overlaid with a granular mucoid protoplasm, the chlorophyll-layer, which gives way at the same time or nearly so that the involution (fold) of the walls, formed by the primordial layer and the youngest lamina of deposit (thickening layer), advances into the cavity of the cell and unites at its centre.

Between the secondary cell and the chlorophyll-layer a colourless mucous fluid collects during this process. This fluid is held by Dippel (Vegetabilische Zellenbildung, 1858, p. 32) to be plasma, which originates in this situation on account of the active generation of tissue going on in it, and which forces the green contents towards the interior as a consequence of its accumulation. Not unfrequently, when this plasma is first seen, there is no perceptible trace of the septum, which subsequently makes its appearance, commencing from the periphery in such a manner that, as it has been described, it seems to be a product of crystallization. But that the delicate walls of the daughter cells may be here actually present, though hidden in the mucoid plasma, the previously recorded action of solution of tannin upon the mucous contents of the cells of *Mougeotia* afford sufficient evidence.

Concurrently with the first indications of the presence of a septum (at times, indeed, previously), the mass of chlorophyll recedes towards the middle line of the cell : it seems as if the green contents were separated all round by the colourless plasma and on each side by the narrow lamina from the neighbouring walls of the joint-cell, and pressed towards the middle line of the latter,—not divided, but for the present constricted (fig. 40).

In this case, however, the constriction or compression of the chlorophyll-mass is only apparent; for a closer examination of this condition shows that the vesicles which form the chlorophyll-layer do not actually withdraw, but have become colourless in the spot occupied by them, whilst the adjoining septum makes its appearance more distinctly. Sometimes a green vesicle remains somewhat longer in the colourless mass, and may be distinctly seen to grow progressively more and more colourless.

The mode of deposition of the elongated starch- and chlorophyll-vesicles in the so-called constriction (fig. 40 *a*) often gives rise to an appearance as if these corpuscles were deposited on the wall of a tube, continually constricted at that part, and particularly so in the last stages of thickening of the septum, where they stand at right angles to it; nevertheless it may be observed, especially in wide cells, that here also at their centre there exists a lighter cavity elongated in the direction of the septum which is undergoing alteration,—a cylindrical body, a cell which exerts its influence upon the deposition of the chlorophyll during absorption.

However, this arrangement of the secretion-vesicles is liable to very great variation : the condition represented in fig. 40 *a*, and previously described, is very often met with; frequently, in this stage, no chlorophyll-vesicles are to be seen outside the endogenous cell undergoing enlargement; but almost as often secretion-vesicles are distinctly visible in abundance externally to the central cell which has been arrested in its development, and not uncommonly so dispersed and irregularly arranged and mingled among the colourless and distended vesicles, that the impression, at first sight, is that they are not enclosed within a special membrane.

It would appear that the secretory material of the chlorophyll-layer in process of absorption servcs, on the one hand, for the thickening, and on the other for the enlargement, of the neighbouring cell-walls (p. 427).

The nature of the cell which probably exists in the interior, and becomes enlarged simultaneously with the thickening of the septum, has not been ascertained.

Conditions like that shown in fig. 46 *q* render it probable that the next younger pair of joint-cells is already developed and undergoes division in the cavity of the joint-cell that is just making its appearance, from the walls of which they are separated only by a small quantity of chlorophyll and starch-vesicles, which are subsequently dissolved gradually.

In the unthickened septum itself, even when it is visible in this state, as in the example represented in fig. 46 *q*, it is very seldom that, with the reagents hitherto employed, the two cell-membranes of which it was composed (fig. 46 *x*) can be demonstrated. Still less can it be decided by observation whether the membrane of these cells in this stage of development belongs to two cells nested one within the other.

Those septa, on the other hand, in which thickening has commenced are capable, in proportion to the extent to which this process has advanced, of being resolved into the different cell-membranes of which they are composed by the action both of endosmotic fluids and of solvents of the recently thickened membrane.

Transitory endosmotic phenomena are produced in many Conferva-cells even by the action of different kinds of water met with naturally, such as spring-, river-, or rain-water, and indeed sometimes by pure distilled water in the case of plants previously grown in other water. Water containing carbonic acid, and other mineral waters, are more energetic.

The action of concentrated carbonic-acid water upon many Confervaceæ (for instance, on *Spirogyra*) is of a complex nature; for, besides diosmosis, a change in the constitution of the cell-membrane takes place: in this plant it causes a swelling up of the young, and an increase of the ligneous condition of the older, cell-membranes.

Endosmotic fluids of more potency, saline solutions, acids, sugar, alcohol, &c., which detach the several adherent membranes of the superposed cells from one another, have an exosmotic as well as an endosmotic action.

Hence the membranes of the secondary cells become contracted and separated from the primary cells with which they were previously in immediate contact, by the action of these reagents; and indeed they detach themselves all round from the external membrane, the separation of these membranes of the two cells not being perfect until the chemical change has commenced but not been completed in one wall. In this case, the membranes continue united where the thickening of the contiguous primary cell-walls has not yet taken place. In the transverse walls or septa this happens, therefore, at the centre, inasmuch as their lignification advances from the periphery, or centripetally. The young joint-cells consequently continue to adhere closely together, apparently wedged into the central opening of the perforated discoid septum, as is exhibited in the case of *Spirogyra*, in Plate VII. fig. 67.

This phenomenon has especially contributed to support the notion that the adjoining daughter cells constituted originally only one single cell, which has become divided by the thickened portion of the septum.

In *Œdogonium* we may convince ourselves, by direct observation, that, notwithstanding these results with reagents, which might serve as arguments for the constriction-theory, there is present a perfect, though it may be an extremely delicate, septum.

The delusion is still greater if, in this condition (fig. 67), a pressure from one side be exercised on the young septum (whether effected by the one-sided operation of endosmotic fluids or by a change of tension caused by the cutting of a cell in the immediate vicinity of the septum), and chemical reagents be then applied to dissolve the cell-membrane which is undergoing a change in its chemical constitution.

That many newly formed cell-membranes, or such as are in course of development, are soluble in water, and still more readily in acetic acid, I have already shown in my above-mentioned memoir on *Conferva fontinalis.* The cell-membrane, in process of thickening, which occupies the central layer of the septum, is dissolved by ammonia and iodine as well as by acetic acid.

Of the above-mentioned solvents of the newly thickened cell-membrane, ammonia appears to have the weakest action; its effect, however, is probably the less striking because it acts endosmotically, and not exosmotically, upon the contents of the secondary daughter cells. However, after the operation of ammonia on the septum, when in course of thickening, and while apparently still simple, the limits of the two daughter cells forming it are distinctly seen; in other words, its construction out of two lamellæ is demonstrated. Iodine, when applied in a concentrated state, has a more energetic solvent action upon the recently thickened primary cell-membrane; and when its solution is diluted, it is at the same time exosmotic in its action on the contents of the secondary cells.

If these solvents be allowed to act for a time upon half-lignified septa, the different component cell-membranes of which have been separated from each other as much as possible by means of diosmotic fluids, the newly lignified septum thus set free is eroded at the centre, and finally more or less dissolved, whilst the two contracted and mutually adherent daughter cells float freely in the cavity of the parent cell. Examples such as that represented in fig. 67, of a *Spirogyra* treated with glycerine and afterwards with a solution of iodine, should therefore be cautiously used in elucidation of the mode of origin of a septum.

In this experiment it now and then happens that one young joint-cell (as shown in Pl. VII. fig. 67) which is adherent by one extremity to its neighbouring sister cell, and with it detached on every side from the mother cell, is at the same time still attached to the opposite end of its mother cell, by which a considerable tension of the young cell in its long diameter is produced, and being transferred to the neighbouring septum, is exerted chiefly on the delicate young wall in process of lignification. This is consequently somewhat drawn into the cavity of the extended cell until it becomes lacerated at its point of union with it, whereupon it again assumes its flat form, and the second daughter cell is drawn through the circular central opening so formed in the septum into the adjoining cell-cavity.

At times the lignified portion of the septum is so delicate that, after the operation of a solution of glycerine, only a very slender annular thread is visible on the inner surface of the mother cell; and it might be supposed that the two adherent contracted secondary daughter cells floated freely in the centre of the mother cell. Upon the addition of a diluted watery solution of iodine, which is greedily taken up by the fluid contents of the primary cell, it is perceived, by the movements thereby induced within the two contracted and coherent daughter cells, that these do not float freely in the centre, but are fixed in their position by the thread-like annular septum, which, from the cloudiness of the cell-fluid, caused by the solution of iodine, appears like an extremely thin clear lamina, and exhibits slight movements corresponding with those of the daughter cells.

The constricted line of union between the two connected daughter cells is not unfrequently colourless; nevertheless it cannot be positively ascertained whether, as appears upon altering the focal distance, and as would correspond with my notion of the origin of the septum, the circularly torn thickened septum is continued as a delicate membrane throughout this uniting band, or whether a fluid constitutes the stratum of separation between the coloured secretion-matter contained in the two daughter cells.

In most instances, even this connective band is concealed by the coloured contents, which are pressed into the median line by the contracted membranes of the secondary cells; and in these circumstances the scar of the lacerated septum exhibits the appearance of a notch in this lamina in the mass of chlorophyll.

The appearances in cells where new septa are in course of lignification are altogether different when rather stronger diosmotic agents are brought into contact with them. In such cases one of the young joint-cells is frequently more strongly contracted than its neighbour; the delicate septum perceptible between them, which usually, in its youngest and unthickened condition, protrudes in a convex form into the upper cell (Pl. VI. fig. 42 *a*), does so, under the condition in question, to a greater degree; the contiguous secretion-vesicles likewise gradually recede into the less extended cell, until at length the septum can no longer withstand the constantly increasing pressure, but gives way before it, and allows a sudden rush of the chlorophyll- and starch-corpuscles from their cavity into the neighbouring one. These phenomena may be readily witnessed in the vicinity of the cut portions of the joint-cells (p. 421).

This translation of the chlorophyll- and starch-corpuscles from one side of the septum to the other, within the expanding cell, and which may especially be seen for a considerable time after the rupture of the septum, might lead those who do not take into consideration the great extensibility of the unthickened cell-wall, and who may not have observed the ultimate rupture of the young septum, to the erroneous belief that no septum existed betwixt the two closely approximated and contracted daughter cells.

However, if, after extension has proceeded for a time, the abrupt and forcible movement of the chlorophyll-vesicles, &c. be first observed, followed by a more gentle one, the operation of diosmosis remaining unchanged, no other inference can be drawn than that an existing obstacle has been suddenly removed, and evidence thereby afforded of the previous existence of a septum, overlaid by those secretion-vesicles, at the spot where the movement occurred.

When the above-mentioned solvents for a cell-membrane engaged in chemical metamorphosis for the purpose of lignification are allowed to act upon a septum in process of thickening (fig. 40 *a*), and a stronger contraction is then induced in one of the two adjoining and adherent daughter cells by the agency of exosmotic fluids, the central and unthickened portion of the septum is torn through, whilst the peripheral walls of the two adherent sister cells remain connected, as indeed was observed although differently interpreted by Mohl (Vermischte Schriften, xiii. 8, 9).

The chemical and physical actions of the above-mentioned commonly employed reagents upon the substance of plants has, however, been by no means sufficiently studied to enable us, from the changes which they produce upon vegetable tissues, to arrive at any certain conclusions as to the structure of the latter. And our knowledge of the mode of action of these reagents upon the membranes of assimilant cells is especially imperfect, because it is different in each new stage of development of the cell, which is in a constant process of change.

The intimate knowledge of the anatomical changes which take place in the cell in the course of development must therefore precede, or at least go hand in hand with, that investigation, the results of which consequently, as yet, are of subordinate value in the appreciation of anatomical conditions.

The mutual adherence of the constituent cell-membranes of the septum (p. 283), which stands so much in the way of a correct recognition of its true nature, appears to be still more inexplicable, under certain circumstances, in fully developed cells. In such cells the still delicate daughter cells are commonly separated with great facility from the parent cell by the action of diosmotic fluids. But if a specimen of *Conferva glomerata* be allowed to lie for some time in a dilute aqueous solution of tannin or of ammonia, and an aqueous solution of iodine be then brought in contact with it, not only are the membranes of the secondary cells loosened from those of the primary, but these last also are partially separated from the mother cell, and the enveloping membrane from the included joint-cells even to the very extremity (fig. 41). All the thickened membranes moreover show very clearly the thickening layers, which are either imperceptible or very imperfectly recognizable in the living plant: this is the case especially after their penetration by a solution of gum arabic. The delicate membranes of the secondary cells are not, however, detached at both extremities, as in normal states, from the primary cell, but maintain their position as exhibited in fig. 47; and as they become contracted by exosmosis, they drag the primary membrane, which lies loosely in its mother cell, after them at both ends, so that the surfaces formed by the septum occur at the base of the retracted extremities of the sac.

This condition consequently shows that, though the two cells concerned in the construction of a septum may, as a rule, not be recognizable prior to its thickening, there is no cause to doubt the presence of those membranes, which is indeed justly deduced from other circumstances.

The stronger cohesion of the two cell-membranes at their extremities indicates a dissimilar chemical constitution in their different regions—a circumstance that also obtains among some cells of the complex tissues of more highly organized plants.

From all the foregoing facts it follows without doubt, that the folds of the joint-cells of *Conferva glomerata*, so far as they can be certainly recognized, have no connexion with the multiplication of cells by fission, and indeed exert no demonstrable direct influence upon cell-multiplication. On the contrary, it has been ascertained that, in *Cladophora*, in certain cases, the septa originate by the growth and mutual contact of the membranes of free endogenous cells; and upon this ground we may perhaps be justified in explaining, by analogy with other instances, the process of normal septum-formation in this plant, which, on account of peculiar complications, cannot generally be recognized with the same distinctness.

[To be continued.]

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## XLI.—*Notice of the Capture of* Mithras paradoxus *in England.* By John Blackwall, F.L.S.

In the 'Annals and Magazine of Natural History' (ser. 3. vol. ix. p. 375), I have stated my belief that, on a careful inspection of *Mithras paradoxus*, it would be found to be provided with four pairs of spinners, and a calamistrum situated on the superior surface of the metatarsus of each posterior leg. An opportunity of establishing the accuracy of this opinion has recently been supplied by my friend Mr. R. H. Meade, who kindly forwarded to me a fine specimen of an adult female of this species that had been taken in the lake district of Cumberland, in the summer of 1863. The capture of this spider, which is now first recorded as indigenous to Britain, is a circumstance of peculiar interest; for, having placed beyond all doubt the fact that it possesses eight spinners and calamistra, every difficulty that has hitherto been experienced relative to assigning it an appropriate position in the systematic arrangement of the *Araneidea* is thereby removed. By its well-marked organic characters, it is